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(54) FILTERING MEDIUM FOR GASES

(71) We, COLLO GESELLSCHAFT MIT BESCHRÄNKTER HAFTUNG, formerly Collo Rheincollodium K&H GmbH, Werk Hersel, of Simon-Arzt-Strasse 2, D-5303 Bornheim-Hersel, Germany, a German Company, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a filtering medium for gases, more especially for filtering air which is charged with gaseous foreign or noxious substances, which can be used in the form of a loose heap or bed of a small-size filter material.

Various types of filtering substances, which can be used in granulated form as a heap or bed, are known for filtering gases. Usually, a more or less thick heaped layer of filtering substance is so arranged in a gas permeable filtering chamber that the medium to be filtered flows through the said layer, and the substances to be filtered out are removed. To be mentioned as an outstanding example of such filters consisting of heaped material are the known active carbon filters, which are widely used particularly because of the high absorption power of the active carbon for filtering gases.

Despite their wide use, the active carbon filters are however not free from disadvantages. A first disadvantage is the tendency of the active carbon to form abraded particles, even under moderate mechanical stress. The pollution which is connected therewith is particularly troublesome and unpleasant when the filters are used for domestic purposes, for example, for air circulation hoods for kitchen fumes, in which the filter has to be replaced at intervals. Furthermore, the fine abraded carbon particles can possibly be discharged from the filter with the medium which is to be filtered. Furthermore, there is the danger of the bed of heaped material, consisting of active carbon slipping in its mechanical holding means and in this way forming short-

circuiting passages, along which the medium to be filtered flows through the filter without coming into contact with the active carbon. In order to avoid this disadvantage, it has been proposed to use filter cartridges in the said kitchen air-circulation hoods, the granulated active carbon being contained in perforated hardboard containers, which are cut to trapezoidal form and of which a relatively large number are placed in the fume-extraction hood.

The active carbon filters have the additional disadvantage that they have only a comparatively limited active life and consequently have to be replaced at regular intervals of, for example, about six to twelve months. It is an additional disadvantage that the absorption power of the active carbon is dependent on temperature and adsorbed substances are liberated again when the filter is heated to 40—50°C.

For removing gases, vapours, smells, etc. from gaseous media, such as more especially air, there are also known catalytically active filters, with which it is possible to achieve a catalytic reaction of the gaseous substances to be removed, even at normal room temperatures. In this connection, a filter has become known in which a fine-pore, hydrophilic and open cellular synthetic plastics foam is used as support material for a catalytically acting Redox system, the catalysts of the Redox system being incorporated in the cell structure of the said foam. More especially employed as Redox systems are oxides of polyvalent metals, such as manganese oxide, iron oxide, copper oxide, cobalt oxide, nickel oxide and silver oxide, in certain combinations. These substances are added in an extremely fine-grain form, possibly together with substances, such as active carbon, which have a sorbing action, to the initial mixture for the foam plastics material, so that they are permanently and unreleasably combined in the cell structure of the foam plastic material after the foaming operation has taken place. Experiments have shown that a filter of this last-mentioned type, which

is used in the form of webs or sheets, can be used with advantage, even at room temperatures, for destroying smells, particularly for eliminating unpleasant odours and noxious substances from the air, which consist for example of albumin decomposition products and the like.

According to one aspect of the invention, we provide a method of purifying a gas which comprises contacting said gas with a bed comprising flakes or granules of an open cellular plastics foam material in which there are incorporated a catalytically active Redox system, the flakes or granules being admixed with at least one substance having a sorbing action.

According to another aspect of the present invention we provide a filter material for gases comprising flakes or granules of an open cellular plastics foam material in which there are incorporated a catalytically active Redox system, the flakes or granules being admixed with at least one substance having a sorbing action. Advantageously at least a major proportion by volume of the flakes or granules have a particle size which is below about 10 mm, and preferably between about 3 and about 5 mm.

The average pore size of the foam plastics particles can vary, depending on the purpose for which the filter according to the invention is used. It is generally between 0.3 and 4 mm, advantageously between approximately 0.5 and 2 mm.

In accordance with one preferred form of the invention there is used active carbon in granule form as a substance having sorbing action. In this case, the proportion of active carbon in the bed is conveniently 10—40% by volume, preferably 15—25%, by volume. The ratio by volume between foam plastics material and active carbon is accordingly preferably adjusted to about 3:1 to 4:1, which corresponds to a ratio by weight between foam plastics material and active carbon of 1:3 to 1:4.

It was found that sorbing substances of small to ultra-fine grain size, such as particularly crushed or ground active carbon, can be mixed in unexpectedly large quantities with a small-size foam plastics material, and that the "absorbing and fixing power" of the flaked or granulated foam plastic material is so great that the extremely fine-grain and dust-like active carbon, in the afore-said large quantities, is almost completely taken up by the foam plastics material and is bonded to the latter mechanically and also by surface forces (van der Waals' forces) so that generally there cannot be any extensive demixing of the substances, even with strong, mechanical stresses of the bed. Particularly favourable conditions as regards the absorbing and fixing power of the foam plastics material are obtained if at least the major proportion of the active carbon has a grain size which is smaller and pre-

ferably considerably smaller than the average pore size of the foam plastics flakes or granules, and if there is used for the latter a fine flake or flock material, which is obtained by tearing a synthetic hydrophilic soft foam on a flocking machine or the like. Such a foam plastics material has a particularly irregular, rough and fibre-like structure, which considerably assists the binder-free adhesion of the carbon particles to the foam plastics flocks. On the other hand, however, there is also the possibility of using foam plastics particles which are adjusted to be medium hard to hard, possibly admixed with soft flocks, which are preferably obtained by mechanical comminution and possibly subsequent screening of foam material adjusted to a medium hard to hard consistency.

The combination of foam plastics flocks which are preferably adjusted to a soft consistency or a granulated foam plastics material with the fine-particle active carbon, the latter preferably being completely or at least predominantly bonded in an intimate distribution to the foam plastics material, leads to a loose material filter, which has outstanding properties in various respects. With such a mixture of loose materials, the active carbon, as stated, is so bonded to the foam plastic material that any separation of ultra-fine grain or dust-like active carbon from the mass of loose material is substantially prevented. Since the active carbon is in addition embedded in the small-size foam plastics material and the latter exerts a certain cushioning or buffering action, there can be no relatively strong abrasion of the active carbon, even with relatively strong swirling or shaking movements of the loose material. This is more especially important when the filter according to the invention is used with portable equipment, as for example with appliances constructed in the manner of electric space-heating appliances for filtering the air in rooms.

Another essential advantage of the filter according to the invention consists in that, because of the active carbon being mixed with the small-size foam plastics material, the filtering resistance can be considerably reduced, for example, as compared with a conventional active carbon filter. Consequently, it becomes possible to work with comparatively large heights of the filter bed or bed thicknesses of the loose material filter, which in turn provides the advantage of long filtering passages and long contact times between the filter material and the medium which is to be filtered. The filtering efficiency is in addition improved by the increase in the active filter surface, which results from the use of the small-size foam plastics material broken down to a greater or lesser degree into fibres. With the loose material filter according to the invention, the effective filtering loose materials are possibly able to carry out a certain cir-

culatory movement and a moderate swirling movement under the action of the medium flowing under pressure through the filter, without this leading to a relatively strong abrasion or to a demixing of the materials. This circulatory and swirling movement also improves the contact between the medium to be filtered and the active filtering substances and has the effect that new filtering paths and contact surfaces for the medium to be filtered are constantly being formed in the filter.

According to a preferred constructional form, the filter according to the invention comprises catalytically active substances of a Redox system, which are included in finely distributed form in the mass of loose material in addition to the substance(s) having a sorbing action. These catalytically acting substances are preferably bonded to the foam plastic, i.e. are added to the reaction mixture of the foam plastics when the latter is manufactured, so that they are "incorporated" by foaming into the foam plastics. However, there is also the possibility of the catalytically acting substances or other additives of such substances in extremely fine-grain form being admixed with the loose mass, so that they are introduced into the pores of the foam plastic material, like the active carbon.

In a filter of the last-mentioned type, the active carbon is thus arranged in finely distributed form and in intimate contact with the catalytically acting substances of the Redox system which are combined with the foam plastic material, so that substances to be filtered out and bonded by absorption by the active carbon are held in the effective range of the catalysts and thus are able to be degraded chemically by the latter. It is here of importance as regards the action of the filter according to the invention that the storage capacity of the filter, i.e. the absorption power of the foam plastics and of the active carbon incorporated therein, is matched to the degradation power of the catalytic substances of the Redox system. Tests have shown that a particularly favourable ratio between storage capacity and degradation power is obtained if the proportion of active carbon in the foam plastic material is at approximately 20—25% by volume and if the proportion of the catalytically active substances of the Redox system is 5—18% by weight, relatively to the weight of foam plastics material.

A filter of this aforementioned type has excellent properties, more especially with the filtering and the destruction by oxidation of kitchen fumes and other evil-smelling gases, particularly those containing sulphur or nitrogen, from the air, such as albumin decomposition products, acrolein, carbohydrate decomposition products, aldehydes, ketones and hydrocarbons. The filter according to the invention thus represents an extremely efficient filtering system, in which the sorbing sub-

stances and the chemically active substances of the Redox system are in extremely fine distribution and in completely intimate contact and which at the same time has an extraordinarily large active filtering surface, which is further assisted by the flocking and the fibre-formation and roughening of the foam plastics which is connected therewith. The destruction by adsorption and oxidation of the gaseous odorous and noxious substances can be carried out in the low temperature range, and above all also in the room temperature range. Consequently, the filter according to the invention can be used with particular advantage domestically, for example, as smell extractors for refrigerators, in fume extractor hoods for kitchens, for removing smells in living rooms, assembly halls and factory shops, in ventilation and air-conditioning installations.

As mentioned, the catalytically active substances, consisting of heavy metals, metal hydrates or oxides, as for example the oxides of iron, manganese, cobalt, nickel, copper or silver, are advantageously incorporated into the foam plastics during the foaming, so that they are combined in the foam plastics cell structure in extremely finely divided form. For the catalytic efficiency in the low temperature range, it is particularly important that the filter, during use, has a certain minimum humidity (a monomolecular water layer is sufficient), in order to guarantee optimum efficiency of the filter. On the other hand, the catalytic reaction depends on a certain pH range of the filter. Thus, a Redox system consisting of the oxides of iron, manganese and copper is particularly effective in the pH range from 8—8.5 when potassium ions are simultaneously present, whereas, for example, a Redox system consisting of the oxides of the metals iron, manganese, cobalt or nickel is particularly effective in the pH range from about 2.4—2.6.

These systems and these pH ranges are obtained by suitable additions at the time of producing the foam plastics material.

The proportion of the catalytically active substances incorporated in the foam plastics material at the time of foaming is preferably about 5—18% by weight and advantageously 5—10% by weight, relative to the weight of the foam plastic. For the flocks, there is advantageously used an open-pore and hydrophilic polyurethane foam material which is adjusted to a soft consistency, although also other hydrophilic foam plastic materials, such as polyvinyl-alcohol foams or phenol resin foams, are also suitable.

The possibility also exists of other substances as for example sorbing substances, particularly bentonite, preferably up to 10% by volume (related to the volume of foam plastics) or other active substances, as for example catalytically active substances of the Redox system, up to 18% by weight (related to the

weight of foam plastics) to be subsequently added instead of or in addition to the active carbon.

- 5 The filter material according to the invention is preferably produced by a foam plastics filtering material of known-type, which consists for example of an open-cell, hydrophilic foam plastics (polyurethane foam) with catalytically active substances of a Redox system
- 10 incorporated therein during the foaming, being torn by means of a flocking machine or the like, and by the forming flock material being thereafter screened on a sieve with a screen mesh of 10 mm. Therefore, as material passing
- 15 through the sieve, there is obtained a soft elastic flock material with a particle size of a maximum of 10 mm, a considerable proportion of said material having a particle size below 10 mm. The flock mixture thus obtained
- 20 of the intimately mixed in a ratio by volume of 3:1 to 4:1 with broken active carbon, this preferably being carried out by means of a mechanical mixer. The active carbon preferably
- 25 has a grain size below 3 mm and advantageously below 1—2 mm, a considerable proportion of the active carbon being in the grain size range of 30—100 μ .

As mentioned, the filter according to the invention can be used for many purposes. It can be employed more especially for all those cases where previously active carbon filters were used. The filter according to the invention is preferably employed for removing unpleasant odours or other undesired or noxious gases from the air, such as particularly for removing odours resulting from cooking and baking, tobacco smoke, alcohol fumes and human perspiration from the air. When filtering air or other gases, it is expedient to use

30 a foam plastics flock material (more especially polyurethane) which is of soft consistency and of which the loose weight is 10—100 g/l, preferably 30—60 g/l. More especially for the destruction of albumin decomposition products, it is advisable to add bentonite, which is preferably incorporated into the foam plastics at the time of foaming.

Several examples are given below:

50 EXAMPLE 1:

- For the production of a catalytically active, hydrophilic, open-cell foam plastic material of soft consistency, 125 parts by weight of a polymeric product of ethylene diamine with propylene oxide and ethylene oxide and 125
- 55 parts by weight of a polypropylene oxide-ethylene oxide mixed product are neutralised with 25 parts by weight of 10% sulphuric acid, whereafter there are added 50 parts by

weight of montmorillonite powder (bentonite), 15 parts by weight of dehydroaluminium silicate of a molecular screen, 3 parts by weight of water, 2 parts by weight of tin diacetate, 9.6 parts by weight of potassium permanganate and 6.9 parts by weight of basic copper carbonate, stirring taking place until a uniform mixture is obtained and the temperature is adjusted to 20°C. Using an intensive mixer, 60 parts by weight of toluylene diisocyanate are added to the said mixture, which is stirred to a creamy consistency and poured into a vessel which can be cooled. A light, soft elastic foam is quickly formed, and this is cured at about 50°C and with a residence time of one hour in a drying chamber.

The polyurethane foam as thus formed, which contains manganese oxide and copper oxide as catalytically acting substances and in extremely finely divided form, bonded into its cell structure is thereafter comminuted by means of a flocking machine and then screened on a 10 mm screen. The material passing through the screen thus has a particle size below 10 mm, the predominant proportion of the foam plastic flakes being in the range from 2—5 mm.

The flock or flaked material obtained in this way is then mixed in a mixer with finely crushed active carbon, the proportion of the added active carbon amounting to 25% by volume, relative to the volume of the unfloated foam plastic. The grain size of the active carbon is for example below 1 mm, preferably between 50 μ and 1 mm.

The mixture of loose materials obtained in this way can now be introduced into a gas-permeable filter chamber of a filter, the height of the heap or the bed thickness of the filter layer being adapted to the intended purpose of use of the filter. Since the foam plastic flakes are soft and elastic, the mixture of loose material can be compressed to a greater or stronger degree in the filter chamber, and by the amount of compression, the filter resistance can be adjusted within comparatively wide limits. Such a filter is particularly suitable for filtering gases, more especially air, which is charged with gaseous foreign substances, as for example unpleasant odorous substances (kitchen fumes), tobacco smoke, alcohol vapours, human and animal perspiration, hydrogen sulphide, sulphur dioxide and other evil-smelling gases and noxious substances.

EXAMPLE 2

Instead of the polyurethane foam material mentioned in Example 1, it is also possible to use a foam plastic material having the following composition:

	parts by weight	which body has an exceptionally large effective filter surface and of which the air resistance can be adjusted within wide limits by the nature and particle size of the flake material and also by the density and thickness of the stitched or needled flake layer. The thickness of the bed of loose mixture needled between the fibre fleeces is for example 5 to 30 mm, advantageously 10 to 20 mm.	
Polyoxypropylene glycol	10		65
Condensation products of ethylene oxide and propylene oxide with ethylene diamine	10		
Sulphuric acid	0.02		
Hydrogen peroxide	0.04		70
Glycerine	0.10		
Methylene chloride	0.60		
Bentonite (finely ground to below 50 μ , preferably below 10 μ)	3.60		
Potash	1.20		
Molecular screen	1.20		75
Catalytic substances of the Redox system, namely:			
Manganese hydroxide	3.60		
Cuprous oxide	2.40		
Ferric hydroxide	0.70		80
Zinc oxide	1.20		
	34.66		
Toluylene diisocyanate	15.0		

The flaking of this polyurethane foam material and the mixing of the active carbon into the flocked material is effected according to Example 1.

EXAMPLE 3

To the initial foam plastics mixture of the polyurethane foam mentioned in Example 2 are also added 5—20 and preferably 8—15 parts by weight of active carbon with a grain size below 3 mm, advantageously below 1 mm, and the said active carbon, during the foaming operation, is incorporated together with the other granular additives into the cell structure of the foam plastic.

The soft foam material as thus produced is thereafter flaked, screened through a 10 mm screen and mixed with active carbon, as indicated in Example 1.

The possibility also exists of the loose materials of the aforementioned type, consisting of open-pore, hydrophilic foam plastics particles in combination with the other additives, advantageously composed of a mixture of foam plastics flakes and granulated active carbon and containing the catalytically acting substances, being embedded between two fibre fleeces and stitched or quilted with the said fleeces, to form a coherent filter body. It was found that a foam plastics flake material with the said additives can be surprisingly well stitched to fibre fleeces and that it is possible to use here light and thin porous fibre fleeces with a weight of 50—200 g/m², preferably 80—120 g/m², without there being any danger of the loose material stitched between the fibre fleeces trickling out of the plate-like or cloth-like filter body. The stitching of the loose mixture leads to a coherent filter body which, depending on thickness, is more or less pliable and at the same time highly porous,

The needling action is effected by the mixture of foam plastics flakes (with incorporated catalysts) and active carbon in a bed height of 10—50 mm, preferably 15—30 mm, being applied to a fibre fleece, for example, a cellulose fleece, with a surface weight of for example 80—120 g/m² and a thickness of for example 1—2 mm, and being smoothed by means of a doctor roller or the like. After laying on a covering fleece, which preferably corresponds to the bottom fibre fleece, the complete laminated body is needled on one or both sides by means of known devices, the number of needle insertions per square centimetre being between 20 and 100. The needling of the laminated body can be carried out in such a way that the layer thickness of the applied loose material is somewhat reduced, with more or less strong elastic compression of the foam plastics flakes. It is possible in this way to adjust the porosity and thus the air permeability of the filter, and also the strength of the filter system.

By means of the needling method as previously described, there is thus obtained a filter in the form of a cloth, a sheet or a continuous length or the like, which can subsequently be separated into individual filter sheets or flakes.

For preventing the flake or grain material, with the transverse cutting of the cloth-like or sheet-like filter body, crumbling or breaking away slightly at the place of cutting, it may be expedient for strip-like or bar-like edge frames, more especially of a soft elastic foam plastics, to be stitched on to the margins of the filter body. Such strips can in addition also be stitched inside the web for strengthening the mat.

The possibility exists of several thing filter cloths or filter sheets or plates of the aforesaid type to be connected one behind the other or laid one upon the other, so that a multi-layer body is obtained, the thickness of

which is several times greater than the thickness of the individual filter body. Multi-layer filters can also be produced in one working step by fibre fleeces or woven fabrics being interposed or laid open.

The invention is further illustrated in the accompanying drawings.

Fig. 1 shows diagrammatically and in simplified form a section through a filter body according to the invention. Indicated at 10 and 11 are two fibre fleeces of natural or synthetic fibres, between which the flaked and granulated active filter material is needled and which preferably have a surface weight of 80—120 g/m². Indicated at 12 is the flaked foam plastics material, in which the catalytically active substances of the Redox system are incorporated in known manner during the foaming. The particle size of the flake material is smaller than about 10 mm, a considerable proportion thereof being in the range from 1—5 mm. This foam plastics flake material is mixed with the fine-grain, adsorbing material, this latter being almost completely contained in the open pores of the foam plastics and being attached to its fibrillated cell walls. Individual active carbon granules are indicated at 13. The needling of the material which is situated between the fibre fleeces 10 and 11 is effected by means of known devices, the fibres of the fleeces 10 and 11 being drawn through the flake and grain material. These fibres are indicated at 14 in Fig. 1. Because the fibres of the two fleeces are anchored to the foam plastics flakes and to one another, there is produced a coherent but porous filter body, in which the flake and grain material is so held that it cannot crumble or break away from the said material. The number of needle insertions per square centimetre is preferably between 20 and 100. The needle insertions are indicated at 15 in Fig. 1.

If the filter bodies according to the invention are for example cut into rectangular sheets or foils, it may happen that the needed ultra-fine grain material will crumble away slightly at the cut edges. In order to avoid this, a marginal frame 16 can be provided as shown in Fig. 2. The frame here consists of narrow synthetic plastics strips 16, which are laid on the margins of the lower fibre fleece 11. The flake and grain material is then introduced into the space between the framing strips 16, whereupon the upper fibre fleece 10 is laid on the loose material which has been spread out flat and then needled in the manner described. The edge strips 16 are at the same time needled between the two fibre fleeces 10 and 11.

In order to increase the tensile strength and the dimensional stability of the filter according to the invention, the filter bodies can be provided with reinforcing inserts, such as more especially additional fibre fleeces or

porous woven fabric inlays, which are needled into the composite body. These inserts can be laid in the flake layer and/or placed flat against the fibre fleeces. In this way, it is possible to produce multi-layer filters in one working step with interposition or laying on of fibre fleeces and woven fabrics. The uniting of the fibre fleeces and the flake layer and also possibly of the additional inserts can also be produced by the chain-stitch needling operation as known *per se* or by a quilted stitch sewing operation.

Loose material filters of the type referred to in Examples 1 to 3 can be used at temperatures up to about 90°C. The filters are highly effective, even at temperatures which are in or below the room temperature range.

WHAT WE CLAIM IS:—

1. A method of purifying a gas which comprises contacting said gas with a bed comprising flakes or granules of an open cellular plastics foam material in which are incorporated a catalytically active Redox system, the flakes or granules being admixed with at least one substance having a sorbing action.

2. A method according to Claim 1, in which at least a major proportion of said flakes or granules have a particle size below about 10 mm.

3. A method according to Claim 1 or Claim 2, in which said bed includes granulated active carbon as a substance having a sorbing action.

4. A method according to Claim 1 substantially as herein described and as exemplified and/or as illustrated with reference to the accompanying drawing.

5. A filter material for gases comprising flakes or granules of an open cellular plastics foam material in which are incorporated a catalytically active Redox system, the flakes or granules being admixed with at least one substance having a sorbing action.

6. A filter material according to Claim 5, in which at least a major proportion by volume of said flakes or granules have a particle size below about 10 mm.

7. A filter material according to Claim 6, in which at least a major proportion of said flakes or granules have a particle size between about 3 and about 5 mm.

8. A filter material according to any one of Claims 5 to 7, in which the average pore size of said flakes or granules is from 0.3 to 4 mm.

9. A filter material according to Claim 8, in which the average pore size of said flakes or granules is from 0.5 to 2 mm.

10. A filter material according to any one of Claims 5 to 9, which includes granulated active carbon as a substance having a sorbing action.

11. A filter material according to Claim 10, in which 10—40% by volume of said filter

material comprises granulated active carbon.

12. A filter material according to Claim 11, in which 15–25% by volume of said filter material comprises granulated active carbon.

13. A filter material according to any one of Claims 10 to 12, in which at least a major proportion of said granulated active carbon has a grain size which is smaller than the average pore size of said flakes or granules.

14. A filter material according to any one of Claims 5 to 13, in which said plastics foam material is a hydrophilic soft foam material.

15. A filter material according to any one of Claims 5 to 13, in which said plastics foam material is a semi-hard or hard hydrophilic plastics foam material.

16. A filter material according to any one of Claims 5 to 15, in which said plastics foam material is a polyurethane.

17. A filter material according to any one of Claims 5 to 16, in which said flakes or granules contain said substances of a Redox system in finely divided form.

18. A filter material according to Claim 17, in which said filter material contains from 5 to 18% by weight based on the weight of said flakes or granules of said substances of a Redox system.

19. A filter material according to any one of Claims 5 to 16, in which said flakes or granules are admixed with said substances of a Redox system.

20. A filter material according to Claim 19, in which said filter material contains up to 10% by weight based on the weight of said flakes or granules of said substances of a Redox system.

21. A filter material according to any one of Claims 5 to 20, further comprising at least one active filtering substances (other than active carbon).

22. A filter material according to Claim 21, in which said active filtering substances comprises up to about 20% by volume of said filter material.

23. A filter material according to Claim 21 or Claim 22, in which said active filtering substance is selected from bentonite, kieselsguhr, alumina, silica gel, fibre material and mixtures thereof.

24. A filter material according to Claim 5,

substantially as herein described and exemplified.

25. A filter element for gases comprising a layer of filter material according to any one of Claims 5 to 24, sandwiched between layers of gas-permeable material.

26. A filter element according to Claim 25, in which said layers of gas-permeable material comprise fibre fleeces.

27. A filter element according to Claim 26, in which said fibre fleeces are made from natural or synthetic fibres selected from cellulose, cotton, polyacrylic, polyamide and polyvinyl fibres.

28. A filter element according to any one of Claims 25 to 27, in which said layers of gas-permeable material weigh from 50 to 200 g/m².

29. A filter element according to Claim 28, in which said layers of gas-permeable material weigh from 80 to 120 g/m².

30. A filter element according to any one of Claims 25 to 29, in which said layer of filter material and said layers of gas-permeable material are united by needling.

31. A filter element according to any one of Claims 25 to 30, in which said layer of filter material is from 5 to 30 mm. thick.

32. A filter element according to Claim 31, in which said layer of filter material is from 10 to 20 mm. thick.

33. A filter element according to any one of Claims 25 to 32, in which the edges of said filter element are secured in a frame.

34. A filter element according to Claim 33, in which said frame is made of strips of foam plastics material.

35. A filter element according to any one of Claims 25 to 34, in which at least one additional woven fabric inlay is needed into said filter element.

36. A filter element constructed and arranged substantially as herein described and as illustrated in Fig. 1 or Fig. 2 of the accompanying drawing.

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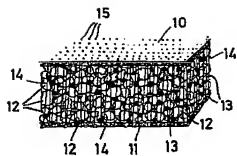


FIG. 1

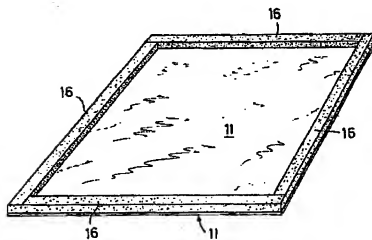


FIG. 2